FARMERS' PREFERENCES REGARDING CLIMATE CHANGE ADAPTATION AND MITIGATION ACTIONS, TOWARDS A SUSTAINABLE AGRICULTURE.

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Abstract: Climate change compromises sustainable agricultural development. It has deep economic, environmental, and social impacts, particularly on vulnerable rural regions in developing countries. This study analyzes farmers' preferences regarding the potential implementation of several mitigation and adaptation actions addressing climate change. Data were collected on 370 farmers in the "Valle del Carrizo" region of northwestern México. Using the Analytical Hierarchy Process (AHP) methodology, the farmers' preferred mitigation and adaptation actions were identified and related to their stated attitudes regarding risks using the Multiple Price List (MPL) lotteries approach. Farmers' environmental beliefs and perceptions as key means of understanding concepts of sustainability were related to their preferences. The use of less polluting machinery and investment in improving irrigation infrastructure were identified as the most preferred actions. Environmental opinions reviewed using the New Ecological Paradigm (NEP) scale allowed for the identification of the participants' ecocentric and anthropocentric attitudes, highlighting the commitment of most farmers to the sustainable use of natural resources. Agricultural policies should be developed according to farmers' preferences and behaviors. The design and implementation of measures and policy tools addressing climate change should be inclusive and developed at the micro-level considering farm and farmer typologies.

Keywords: Agricultura, adaptation, mitigation, farmer's preferences.

1. Introduction

Climate change is one human challenge, ways in which weather events are developing pose social, economic, and environmental risks. Climate change compromises sustainable agricultural development. Climatic patterns are the most significant input factor for agricultural production, their variability is closely related to output productivity. Agricultural sector constitute an important source of greenhouse gas emissions, which is closely related to climate change [Rivera & DiPaola (2013)].

Agriculture is essential to livelihoods in rural and marginal areas. Agricultural policies and public intervention in rural communities are necessary tools that contribute to poverty reduction as part of an economic and social development approach.

In the study region climatic conditions are extreme and have in recent years become even more atypical with high levels of precipitation occurring over short periods and with lower temperatures than normal recorded. Climate change effects are heterogeneous in different regions, therefore, implementation of strategies to adapt production in agricultural systems or mitigate effects of climate change on outputs must be implemented according to each region, farmers' characteristics and farming activities [Aguilar et al., (2018)].

Adaptation actions corresponds to initiatives and measures focused on reducing vulnerability of natural and human systems to effects of actual or expected climate change. Mitigation actions are measures adopted to reduce greenhouse gas emissions and/or encourage elimination of carbon through sinks. Understanding farmers' views and perceptions regarding climate change and actions that they consider most effective against its impacts is critical. Analysis of farmers' preferences for different mitigation and adaptation actions can lead to development of more sustainable agricultural systems.

Within this context, our objectives were to identify relative importance of several climate change adaptation and mitigation actions related to agriculture activities in a region in México in order to guide policy makers through prioritized solutions that contribute to sustainable agricultural systems [IPCC, 2014].

2. Materials and Methods

Data was collected through a survey to 370 farmers from Irrigation District 076 an agricultural area in northwestern Mexico. Questionnaire was divided into several blocks as: 1) farmers' preferences for climate

change adaptation and mitigation actions, 2) environmental attitudes derived from NEP scale, 3) stated risk attitudes derived from MPL, and 4) farmers' socio-economic features and farm characteristics.

2.1 Description of the AHP methodology

AHP method is a multicriteria analysis tool. It allows for the improvement in decision-making processes, in turn generating added value in terms of knowledge. The AHP technique has been widely used in agricultural research mainly in analyzing farmers to establish priorities in decision making, resolve agrarian and environmental problems and analyze marketing issues related to consumers' preferences [Kallas et al. (2012)]. AHP method involves 3 main stages: modeling, assessment, and synthesis.

Modeling. - includes problem definition and structuring a decision model in hierarchy form.

Graphic 1. Decision hierarchy model

Assessment. – in this stage are evaluates all elements of each cluster level (Graphic 1) using verbal scale of paired comparisons proposed by Saaty, where value of (1) means that both criteria are of same importance, (3) means that preferred criterion is slightly more important than the other, (5) preferred criterion is moderately more important, (7) preferred is much more important, (9) preferred is significantly more important and (2, 4, 6, 8) are made to define relative importance of compared elements. Pairwise comparisons were collected using the scheme outlined below:

Table 1. Comparison of measures (cluster 1)

A. Adaptation Measures								M. Mitigation Measures								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

2.2 New Ecological Paradigm (NEP) Scale

Environmental attitudes cannot be observed directly, and thus, it must be inferred through positive or negative environment evaluations. Individuals' environment views can be revealed from their perceptions and attitudes. NEP scale, and exploratory factorial analysis (Principal Component Analysis) were performed to identify dimensionality that characterizes farmers by associating scale's items with several independent dimensions. Identified dimensions define latent factors present in participants' environmental attitudes [Gomera et al. (2013)]. First component was referred as anthropocentrism, it was measured with affirmations focused on supremacy of humans over nature. Second component, ecocentric dimension, was measured with statements focused on unbalanced state humans have created in nature.

2.3 Stated risk attitude

Stated risk attitude is related to human behavior. Individuals prefer options ensure more utility based on their risk preferences [Mejía (2015)]. Multiple Price List method allows us to identify levels of risk tolerance or aversion through a set of questions posed to decision makers "farmers". The method examines 8 scenarios with different lottery pairs where one lottery option (option A or option B) is chosen. The level of risk aversion is based on the number of safe answers (option A) of interviewed farmer selects. In model, safe option (option A) corresponds to 100% probability of succeeding, and risky option (option B) corresponds to 50% probability of obtaining \$100 and 50% probability of obtaining \$0 (based on a coin

toss) in all scenarios. Amounts provided by option A are progressively decreased across all 8 scenarios to the following amounts: \$100, \$75, \$60, \$ 50, \$40, \$30, \$20, and \$10.

3. Results

Results reflect farmers' prioritization of diverse ways to face impacts of climate change on their activities. Estimated average weights show that mitigation actions were deemed the most important options with a higher relative relevance of 58.18%. For each farmer we then estimated actions deemed the most preferred (Graphic 2). Use of renewable energy was the least preferred option and was selected by 5.95% of farmers.

Graphic 2. Farmers' preferences for climate change adaptation and mitigation actions.

According to results of PCA applied to items of NEP scale, two main relevant behaviors are identified: ecocentric and anthropocentric environmental attitudes. A +eco denotes that farmers agree with ecocentric attitudes, -eco denotes farmers disagree with ecocentric attitudes, +anthro denotes farmers agree with anthropocentric attitudes, and -anthro denotes that farmers disagree with anthropocentric attitudes.

The farmers' distribution on four quadrants shows that the majority (39%) exhibited a clearly positive ecocentric attitude (+ eco, - anthro), highlighting positive views of the environment in the studied region. However, 27% of the farmers exhibited a clear anthropocentric attitude (- eco, + anthro). The remaining farmers exhibited less clearly defined opinions, 15% exhibited negative while 19% exhibited positive views toward ecocentric and anthropocentric attitudes.

Graphic 2. Farmers' preferences according to their ecocentric and anthropocentric attitudes (4 quadrants).

Ecocentric and anthropocentric dimensions are closely related to farmer's preferences, most preferred climate change adaptation and mitigation action (M4) was principally selected by farmers who exhibited a positive view of environment. Mitigation and adaptation actions were also more important for farmers exhibiting more ecocentric views of environment (+eco, -anthro). As an exception, one action (to introduce improved and resistant seeds, A3) was preferred more by farmers that do not exhibit a clear attitude toward environment (+eco, +anthro). Results show that farmers with most ecocentric attitudes (+ eco, -anthro) exhibited strongest preferences for use of renewable energy (M3). MPL results show that 51.35% of farmers are risk averse, 7.57% are neutral, and 41.08% are risk tolerant.

Farmers without crop insurance prefer “change crops”, while those with insurance prefer “use less polluting and energetically efficient machinery” to reduce climate change impacts. On other hand, framers with crop insurance have less concerns regarding impacts of climate change and thus exhibit a preference towards other actions that principally reduce negative effects on the environment. Farmers with credit for farming activities and agricultural insurance and belonging to an agricultural association prefer “use less polluting and energetically efficient machinery” and grow onions, chili peppers, corn, soybeans, sorghum, and triticale. Furthermore, farmers without credit for farming activity and with private property under a land tenure regime who grow sweet potatoes prefer to increase investment in irrigation infrastructure. Mitigation action “zero tillage” was preferred by farmers without credit for farming activity, who do not belong to an agricultural association.

Finally, farmers under 40 years age prefer “investment in improvement irrigation infrastructure,” farmers 40 to 60 years age prefer “change crops”, and farmers over 60 years o prefer “zero tillage management.”

4. Conclusions

Enhance effectiveness of policy makers, stimulating preferred farmer actions may guide current public support to prioritize measures that promote the development of more sustainable agriculture activities at regional and national levels

To effectively face impacts of climate change on agriculture implies the implementation of mitigation and adaptation actions according to farmers’ interests and preferences. In general terms, farmers tend to prefer adaptation or mitigation actions because this are perceived to offer benefits sooner when adopted. Farmers with ecocentric attitudes exhibited a greater willingness to adopt measures against climate change, while those with anthropocentric views principally exhibited stronger preferences for activities related to improvements in their productivity. The use of efficient, less polluting machinery was identified as one of the best alternative options not only due to its positive impacts on the environment but also due to its economic benefits in terms of reducing energy costs.

Agricultural public policy decisions must consider farmers’ preferences towards mitigation and adaptation actions when designing and implementing measures that ensure sustainable agriculture. Policy tools and interventions must be inclusive and developed at the micro-level based on farm typologies, and crop diversity must be encouraged.

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